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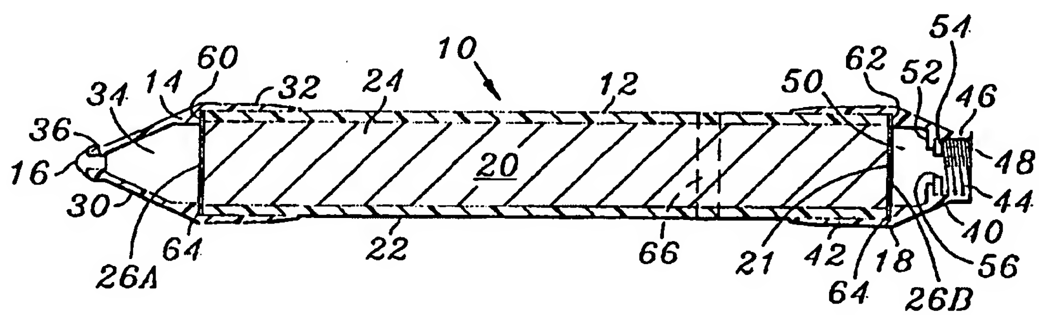

(57) Abstract

A hand-held water demineralizing sprayer (10) comprising a body having a spray nozzle (16) at the discharge end, a water demineralization resin bed (20) within the sprayer and a first chamber (50) for introduction of water into the resin bed. The water flow rate through the sprayer (10) is metered by the spray nozzle (16) to ensure demineralization of the water with minimal use of the resin bed and to produce an output spray at a decreased flow rate. The first chamber (50) can be either a means for attachment to a hose (44), or a receptacle for retaining water. The sprayer (10) has optional means for determining when the demineralization resin is spent. The sprayer can optionally have a means for maintaining shape and integrity of the bed by filling the void volume in the resin bed chamber caused by the volumetric decrease of the resin bed as it is exhausted.

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LIGHTWEIGHT PORTABLE DEVICE FOR CONVERTING TAP WATER INTO A SPRAY OF DEMINERALIZED WATER

FIELD OF THE INVENTION

The present invention relates to a lightweight portable device for converting tap water into a spray of demineralized water, and, more specifically, a portable device for producing a controlled spray of deionized water.

BACKGROUND OF THE INVENTION

In spite of often extensive processing at community treatment plants, water obtained out of a tap contains numerous impurities, including chemicals and/or minerals. The standards set by the U.S. government permit up to 500 parts per million (ppm) of dissolved solids in water for human consumption. Depending on the extent of the impurities in water from the community source, and the purpose for which the water is to be used, the tap water is often treated on-site using techniques such as reverse osmosis and deionization to remove the majority of the minerals from the water. On-site systems for treatment of the tap water range from large scale commercial systems for use in, for example, integrated circuit processing, food processing, or commercial car washes, to in-home water purification systems which remove minerals from hard water and/or remove chemical and mineral impurities that give the water an unpleasant taste. In most installations of home water purification systems, the treated water is piped inside the home, for drinking, or washing clothes or bathing, sometimes because the water is not suitable for outside use, such as softened water, and often because the capacity of the purification system is so limited as to preclude general use.

Anyone who has ever washed an automobile and has not been quick enough to completely wipe off any water remaining after a tap water rinse has experienced the difficulty of dealing with water spots, which are mineral deposits remaining after the water has evaporated. This problem is most pronounced on dark-colored cars, especially if they are washed in direct sunlight. If left on the paint, these mineral deposits can react with moisture in the air to slowly etch the surface, resulting in permanent damage to the car's finish. Those who have washed windows or other smooth surfaces have encountered similar frustrations in

racing against the evaporation rate of the water to wipe the surface clean before the water spots form.

Many commercial car washes have dealt with this problem by installing rinse systems which dispense demineralized water; however, such systems are costly and very large, making them impractical for home use. Where small scale rinsing of delicate surfaces is required, such as rinsing sculptures or other works of art, deionized water can be dispensed from a trigger spray bottle or pressure sprayer. While this practice may be acceptable for smaller items, it would be tedious and impractical for rinsing the relatively large surface areas of vehicles such as cars, trucks, airplanes and boats, especially since the output volume and pressure of the sprayer may not be enough to rinse such large areas effectively, and the fluid capacity of a container that is small enough to make it easily maneuverable would require frequent refills.

The prior art teaches a number of different filtration methods including mechanical filters and mechanical filters combined with chemical adsorbents (see., e.g., U.S. patents No. 3,883,428 of Waring, entitled "Filter"; No. 3,883,428 of Barley, entitled "Orally Operable Water Filter"; No. 4,378,293 of Duke, entitled "Water Filter"; No. 4,678,571 of Hosaka, et al., entitled "Water Purifier"; and No, 4,696,742 of Shimazaki, entitled "Active Carbon Fibers and Filter Adsorption Unit for Water Purification Comprising Said Fibers", the disclosures of which are incorporated herein by reference). While such filtration methods may provide cleaner, better tasting drinking water, they cannot remove ionically suspended minerals from the water, and thus will still leave water spots unless the rinsed surface is wiped dry. Further, unless the filtration systems are very large, or have a large storage tank downstream from the filter, they cannot produce a sufficient volume of water to provide a sustained spray. These drawbacks are also present in reverse osmosis purification methods which, although more effective than simple mechanical filtration, being capable of bringing mineral content down to about 10 ppm, they still cannot completely remove the smallest ionically-suspended minerals, in addition to the fact that such systems can be quite expensive and have limited capacity.

Deionization, in which cation and anion ion exchange resins are used to bind the suspended minerals and remove them from the water, is well known as being highly effective. Examples of water purification systems based on ion

exchange resins are disclosed in U.S. Patents No. 4,826,594 of Sedman, entitled "Portable Water Conditioning Apparatus"; No. 4,913,808 of Haque, entitled "Subcompact Interchangeable Cartridge Drinking Water Purification System"; No. 4,995,976 of Vermes et al., entitled "Water Purification Straw"; and No. 5,126,044 of Magnusson et al., entitled "Iodine Resin/Carbon Water Purification System", each of which is incorporated herein by reference. A major disadvantage of ion exchange systems is that, in order to produce sufficient volumes of deionized water such as would be required to rinse the surface of, for example, a car, large beds of resin are required, which are very expensive, thus limiting such systems to commercial use. Further, storage tanks are often required downstream from the resin bed since the rate of treatment of the water is often not sufficient for real time generation of an acceptable output pressure and/or volume.

The portable filter of Sedman is a canister filled with charcoal and ion exchange resin which is connected in-line in the household plumbing and, thus, when in use, loses its portability when filled with water. The weight of the filled canister would be similar to that of a conventional pressure sprayer--on the order of twenty pounds or more--and would require a hose for dispensing, which, combined, would significantly impair mobility when moving around a large object such as a car, or when rinsing widows around a building. Further, to provide a sufficient flow rate through the filter so that water is readily available at consistent pressures at the faucet, the resin capacity would likely be exceeded, such that complete ion exchange does not occur, and all minerals are not removed. The straw of Vermes, et al. is of interest in its portability and ease of handling. However, since the straw is intended for drinking and, therefore, deals with very small volumes and flow rates, providing sufficient output pressure to generate a spray is not an issue.

Accordingly, the prior art has failed to provide teachings of a lightweight and readily portable, economical device and method for "real time" conversion of tap water into demineralized water which can be used to, among other things, rinse surfaces after cleaning without leaving water spots if the surface is not wiped dry. It is to such a device and method that the present invention is directed.

SUMMARY OF THE INVENTION

The present invention is directed to a method of washing an article, including vehicles whereby the article is first washed with an aqueous solution,

optionally containing organic components and cleaning materials; rinsing the cleaned and washed article with ordinary tap water to remove the washing solution; and then rinsing off the tap water rinse employing demineralized water. The article does not have to be dried; the surface does not have to be squeegee-ed off; the surface can be allowed to air dry in or out of the sun to yield a surface free of mineral spots.

In a first exemplary embodiment, the portable sprayer comprises a longitudinal body with the central cavity, an inlet end and an outlet end; a hollow discharge cone having a discharge outlet attached to the hollow body, the discharge cone having a collection chamber in fluid communication with the central cavity of the hollow body, the discharge outlet in fluid communication with the collection chamber; a hollow inlet piece attached to the longitudinal body, the inlet piece having a distribution chamber in fluid communication with the central cavity of the hollow body, the inlet piece having an inlet in communication with the distribution chamber for the admission of water into the sprayer; first and second porous separators separating the central cavity of the longitudinal body from the collection chamber of the discharge cone and separating the distribution chamber of the inlet piece from the central cavity of the longitudinal body; a spray nozzle attached to the discharge outlet and in communication with the discharge outlet whereby demineralized water is discharged out of the sprayer as a fine spray through the nozzle; an acid for demineralizing ion exchange resin loaded in said central cavity of the hollow body between the first and second porous separators, the resin capable of demineralizing water, and a means of determining when the demineralizing capacity of the resin is spent.

Preferably the inlet end of the sprayer will have a female hose nip for receiving the male hose nip of a hose and, optionally, a valve to control the flow of water through the sprayer. The valve will at least be able to turn water flow into the sprayer on or off.

The means for determining when the demineralizing capacity of the resin is spent comprises a means for determining when the volume of the ion exchange resin has been reduced to a predetermined level. For a given amount of resin, fresh resin requires a larger volumetric space than the exhausted or spent resin. To determine when the resin is exhausted, the present invention provides a way of viewing when the volume of the resin has been reduced to a predetermined level.

At the predetermined level, the resin is exhausted or spent and can no longer demineralize water and can no longer be us d as a rinse.

The spray nozzle is an important aspect of the invention in that it meters the water flow through the resin bed to increase residence time of the water within the resin chamber to assure effective treatment of the incoming water while minimizing the rate of use of the resin, and that it produces a pressure drop at its outlet so that a spray is generated. The low rate of use of the resin is a significant advantage of the present invention since it greatly reduces the amount and, thus, the cost of the resin required for effective operation. Further, the reduced water volume in the output spray results in a significant reduction in total water usage while still providing enough water for effective rinsing. The shape of the outlet can be selected to produce a spray of a specific shape. In the preferred embodiment, a flat spray is formed by an oval aperture in the tip. Conical or rounded sprays can also be produced. Preferably the water flow rate through the sprayer is metered by the spray nozzle to a flow rate between about 18 to about 95 fluid ounces of water per minute per 18 ounces of resin (aspect ratio of about 1 to 7) at a water pressure of about 60 psi to obtain spray water having a total dissolved solids (TDS) or mineral content of 50 ppm or less. Originally it was believed that a spray rate of 28 to 34 fluid ounces per minute was optimum for rinsing. We have found that about 40 to 70, preferably about 60, fluid ounces per minute is preferred for rinsing.

In one embodiment of the present invention, the longitudinal hollow body is made from transparent or translucent material. An indicator, such as a score line, decal, paint spot, or the like is placed on the appropriate position of a hollow body. The sprayer is held in a vertical position allowing the resin to fall downwardly to the outlet end or front end of the sprayer. When the volume of the resin has been reduced by about 20%, the resin is spent. This is an appreciable volume reduction and can be easily seen in the transparent hollow body. The critical volume reduction can be quickly determined by comparing the resin bed height in the longitudinal body when the body is held vertically with the indicator on the body. Likewise, a longitudinal body having translucent walls can longitudinally be held vertically to allow the resin to fall downwardly to the outlet end of the sprayer backlit by a strong light source to determine the resin bed height. The resin bed forms a dark zone in the longitudinal body and permits the height of the resin bed to be easily determined and compared to the indicator on the body. The resin bed is

gauged against the indicator mark on th wall of the hollow body to determine if the resin volume has been reduced to the critical value indicating that the resin is spent.

In another embodiment of the present invention, the longitudinal body can be made from a translucent or opaque material with a strip window running the length of the body molded into the hollow body during extrusion or injection molding. The wall of the longitudinal body at the position of the strip window preferably has an indicator to mark the critical volume of resin that shows when the resin is exhausted (the resin decreases in volume as its demineralizing capacity is spent). Once again, the sprayer is held vertically to prevent the resin to fall downwardly to the front of the sprayer.

Alternatively, the hollow body can be manufactured with a window in the wall at the position where the top of the resin bed will sit when the resin has reached the point of exhaustion. By looking in the window, and seeing the top of the resin bed, the user would know that the sprayer has exhausted its ability to demineralize water and should no longer be used for spraying.

In another embodiment of the present invention, the hollow discharge cone and/or hollow inlet piece can be manufactured from transparent or translucent materials. When the hollow discharge cone and/or the hollow inlet piece is transparent, the height of the resin bed can be quickly determined to determine if the resin has become exhausted. When the hollow inlet piece and/or the hollow outlet cone is translucent, the sprayer is designed so that the top of the resin bed will lie within the cone or piece so that the top of the resin bed can be determined by its shadow when the spray is held up to a strong light source.

The sprayer can also utilize a resin that undergoes a color change when the resin is exhausted. In order to see the color change, either the longitudinal body and/or the hollow outlet cone and/or the hollow inlet piece must be transparent to view the color change. Some cation demineralizing resins are a purple color when fully charged and become a pale yellow straw color when the cation resin is exhausted.

In another embodiment of the present invention, the central cavity of the hollow body is fitted with one or more compacted sponges when the central cavity is packed with the fresh demineralizing resin. As the resin volume is reduced during use, the sponges expand to keep the central cavity space occupied and

force the resin towards the opposite end of the central cavity. A single sponge is positioned next to the porous separators near the inlet end of the d mineralizer. Alternatively, two or more sponges can be employed with a sponge positioned next to each porous separator. As the resin volume is reduced during use, the two sponges expand to force the resin towards the middle of the central cavity.

In another embodiment of the present invention, a third and fourth porous separator means are positioned near the first and second porous separators respectively. A strong spiral spring is positioned between the first and third porous separator and between the second and fourth porous separator. The springs are biased to push the separators apart.

The demineralizing resin is loaded between the third and fourth separators. As the resin volume is reduced during use, the springs push the third and fourth separators away from the first and second porous separators and push the resin towards the center of the central cavity. Alternatively, the sprayer can be fitted with only a third porous separator positioned next to the second porous separator with a spring situated between biasing the two separators apart. In that instance, the resin is loaded between the first porous separator and the third porous separator. As the volume of the resin is reduced and becomes spent, the spring biases the third porous separator away from the second porous separator and forces the resin bed towards the first porous separator. The sponges (or springs) and the separators combination provide ways of maintaining the resin as a compact bed, especially for a horizontal bed, during use of the demineralizer. This arrangement minimizes the opportunity for short circuiting occurring in the bed, i.e., the condition which permits water to pass a short distance through the bed or completely circumvent passage through the bed for demineralizing treatment.

In the above embodiments wherein the resin bed is maintained as a compact bed, the window and the critical resin volume indicator must be designed or positioned so that the bed height or volume can be detected to indicate when the resin is spent.

In yet another embodiment of the invention is a bottle that is of a size that can be easily carried in the user's hand. The bottle is filled with tap water and the uptake tubing that draws the water up for discharge has a chamber in-line with the tubing which is filled with ion exchange resin. The spray nozzle at the discharge end of the tubing meters the water flow to control water flow rat within the resin

chamber and causes a pressure drop at its outlet to form a fine spray through the nozzle. As in the previous embodiments, the relatively reduced flow rate through the resin chamber increases residence time to assure effective interaction between the input water and the resin, and allows efficient use of a small volume of resin. The pressure differential between the resin chamber and the outlet can be created either by using a conventional trigger spray pump device, which creates a vacuum upstream from the resin chamber to pull the water upward, or by providing an air pump to inject air pressure into the bottle which forces the water through the resin and out of the spray nozzle. Optionally, the bottle can have on-off valve upstream from the resin chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

Understanding of the present invention will be facilitated by consideration of the following detailed description of a preferred embodiment of the present invention, taken in conjunction with the accompanying drawings, in which like reference numerals refer to like parts and in which:

Fig. 1 is a cross-sectional view of the sprayer of the present invention;

Fig. 2 is an alternative embodiment of the sprayer of the present invention;

Fig. 3 is a cross-sectional view of still another embodiment of the sprayer of the present invention;

Fig. 4 is a cross-sectional view of the sprayer of the present invention with spent resin;

Fig. 5 is a plan view of an embodiment of the sprayer of the present invention showing the level of spent resin;

Fig. 6 is a cross-sectional view of a fourth embodiment of the present invention'

Fig. 7 is a cross-sectional view of an alternate embodiment of the outlet cone;

Fig. 8 is a rear end view of the outlet cone looking toward the outlet;

Fig. 9 is a cross-section view of a second alternate embodiment of the outlet cone;

Fig. 10 is a cross-sectional view of a fifth embodiment of the present invention;

Fig. 11A is a front view of an outlet end of the present invention and Fig. 11B is a cross-sectional view taken along line 11B-11B of Fig. 11A;

Fig. 12 is a sixth embodiment of th present invention; and

Fig. 13 is a seventh embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to Fig. 1, the present water demineralizing sprayer 10 comprises a longitudinal hollow body 12, a discharge cone 14, a spray nozzle tip 16, an inlet piece 18, and water demineralizing resin 20. The hollow body 12 has a continuous wall 22 which encloses the sides of the hollow body, encloses the sides of central cavity 24 which is in communication with the open ends 26A and 26B of the hollow body.

Hollow body 12 is of a size that can be readily held within an average person's two hands, and is preferably easily supported using one hand so that the other hand is free to wipe the surface being rinsed, if necessary, or to hold an obstacle out of the way, e.g., a windshield wiper, so that the spray can be dispensed uniformly. Typically, the hollow body will be on the order of 15-18" long and 2-22.5" in diameter. It should be noted that the outer shape of hollow body 12 need not be completely circular in cross-section, nor does it need to be a smooth surface, but may be modified for aesthetic purposes and/or to make the sprayer easier to hold, e.g., recessed areas or ridges for easier gripping.

The discharge cone 14 has a conical section 30 and a sleeve section 32 which receives one end of the hollow body. Within the conical section 30 is discharge chamber 34 which is in communication with the central cavity 24 and in communication with the discharge outlet 36 of the discharge cone. The spray nozzle tip 16 is fixed within the discharge outlet 36.

The inlet piece 18 has a hose or trigger sprayer attachment section 40 and a sleeve section 42 which receives the other end of the hollow body. The inlet end 44 of the inlet piece 18 has a female hose nip 46 with internal hose of sprayer attachment threads 48. The female hose nip is in communication with the distribution chamber 50 which is in communication with the central cavity 24 of the hollow body. A retainer wall 52 partially separates the female hose nip inlet from the distribution chamber. A restrictor washer 54 is positioned at the base of the hose nip and is restrained by the retainer wall 52. The bore 56 of the restrictor

washer is or can be adjusted to act as a flow controller. When the tap water is under very high pressure, such as water exceeding 150 psi, the bore will be smaller than when the tap water is under low pressure such as 35 psi. The principal flow control is via the spray nozzle 16. Screens 64 are positioned at both ends of the hollow body. The screen 64 is nestled between the shoulder 60 of the discharge cone 14 and the shoulder 62 of the inlet piece and the ends of the wall 22 of the longitudinal hollow body.

Spray nozzle 16 reduces water flow through the resin bed 20 in central cavity 24 to assure effective interaction of the incoming water with the resin while minimizing the rate of use of the resin. The nozzle 16 also produces a pressure drop at its outlet so that a spray is generated, providing the desired coverage and output flow rate for effectively rinsing relatively large surfaces with a minimum amount of water.

The metering function provided by the nozzle is an important aspect of the invention that makes it effective and economical. Suppliers of deionizing resins specified as "semiconductor-grade mixed bed resins" recommend that water flow be limited between 3 and 7 gallons per minute through one cubic foot of resin in order to reduce the water mineral content to less than 1 ppm. Unfortunately, this flow is too slow to provide an adequate spray to rinse an automobile with a hand-held spray device because of excess size and resin weight required. However, in the present invention, the spray nozzle has dimensions that reduce the water flow to allow economic usage of resin while assuring a sufficient residence time of the water within the resin bed to provide a level of deionization that will permit rinsing of objects without concern about formation of water spots. In the present invention, the spray nozzle limits that flow through the resin to the equivalent of 12 to 14 gallons per minute through one cubic foot of resin for semiconductor-grade mixed bed resin. This flow rate is sufficient to provide water with fewer than 50 ppm TDS (total dissolved solids). Beyond this flow rate through the resin, deionization is not sufficient, and spotting is likely to occur.

Variation of the spray nozzle dimensions can adjust the yield to meter the water and provide flow rates required for effective rinsing at water pressures of about 60 psi, which range between 18 and 95 ounces per minute, preferably about 40 and 70 ounces per minute, most preferably about 60 ounces. In the preferred embodiment, the nozzle 16 is selected to yield around 40-70 ounces of water per

minute at most normal household and hose pressures, which typically rang from about 60-90 psi. Where water pressures exceed this amount, it may be desirable to include a flow restricting washer at the input of the device, since faster flow rates will accelerate exhaustion of the resin.

At the above flow rates a medium-sized vehicle such as a sedan can be rinsed off easily in five minutes. For larger vehicles such as vans, pick-up trucks and sport utility vehicles, it takes approximately seven minutes to completely rinse off a vehicle. For smaller cars, such as small sports cars and compacts, the vehicle can normally be rinsed off in about three minutes. At the suggested flow rates, for a resin bed column 1.75" in diameter by 12.5" in length, the column provides about 25-30 minutes of continuous use with inlet water having about 700 ppm TDS to provide a spray of deionized water with less than 10 ppm TDS. The resin removes both cations (e.g., calcium, magnesium and iron), and anions (e.g., carbonate, sulfate and phosphate). For effective rinsing of any given surface, the resin is considered to be exhausted when the resin bed becomes incapable of producing deionized water with fewer than 50 ppm TDS.

For light-colored vehicles, if the vehicle is rinsed with water having a total dissolved solids content of between 50 and 100 ppm and allowed to air dry, residual water spots, while present, are hard to detect. However, with a dark-colored car, the same rinse will result in noticeable water spots if the car is allowed to air dry. Therefore, for the most effective operation, a content of less than 1000 ppm TDS is important, with less than 50 ppm TDS preferred.

In addition to variation of the size of the spray nozzle to adjust flow rate and control residence time of the water in the resin bed, the shape of the outlet in the spray nozzle can be selected to produce a spray of a specific shape. In the preferred embodiment, a flat fan spray is formed by using an oval or cat's eye aperture in the tip, which is illustrated in Figs. 11A and 11B. The cat's eye aperture 300 is centered at the apex of outlet cone 314. Ribs 320 may be molded or firmly attached to the apex to provide additional pressure resistance to the tip 316 and to protect the aperture 300 from contamination or damage. In order to produce the desired yield (28-32 oz.) and pressure drop in the preferred embodiment, the dimensions of the aperture are approximately 0.25 in. (~6 mm) high and 0.56 in. (~14.2 mm) wide. Conical or rounded sprays can also be produced using round apertures with or without a concentric obstruction.

Referring to Fig. 2, the wat r demineralizer sprayer 10A has the same elements as the water demineralizer sprayer 10 of Fig. 1 with the following exceptions: the sprayer 10A has a transparent window 70 in the wall 22 of the hollow body. The window has a line 72 in the middle of the window to indicate where the resin bed height from the front or outlet end of the sprayer is when the resin is spent and will no longer effectively demineralize water. The window 70 is made of a clear material such as clear plastic, acrylic or the like. However, a translucent window can also be utilized although it is far easier to see the bed height with a transparent window. This is especially true when the wall 22 of the hollow body is made from opaque material which blocks all light from entering into the central cavity. Alternatively, rather than determining the resin bed height, a window can be placed anywhere along the longitudinal hollow body to determine the color the resin when color-changing resin is utilized. When the resin has reached the point of exhaustion, it will make a color change which can be viewed through the window.

Referring to Fig. 3, the sprayer 10B of Fig. 3 has all the elements of the sprayers of Fig. 1 and Fig. 2 with the following exceptions: the sprayer 10B has two compressed sponges which have expanded and because the resin bed 20A is spent. One sponge is situated at the spray or outlet end of the sprayer and the second sponge is situated at the inlet end of the sprayer. The sponge is porous and permits water flow through the sponge from the distribution chamber 50 into the resin bed 20. A single compressed sponge or a plurality of compressed sponges can be utilized. Sufficient compressed sponges are utilized to force the top of the resin bed down towards the spray or outlet end of the sprayer 10B.

The spent resin bed 20A top 21 can be seen in the window 70A (shown in phantom). Once the top of the resin bed can be seen in the window, the user knows that the resin is exhausted and no longer will be able to demineralize water. As shown in Fig. 3, there is a porous separator 76, such as a screen or porous filter positioned between the sponges 74 and the resin bed 20A. The outer diameter of each separator 76 is slightly less than the internal diameter of the longitudinal hollow body 12. This permits the separators to move within the central cavity as the resin volume reduces and the sponges expand. The separators help to maintain the integrity of the resin body 28 and minimize the passage of resin

around the outer periphery of the sponge 74 b tween the out r periphery of the sponge 74 and the inner wall of the longitudinal hollow body.

Referring to Fig. 5, the water demineralizing sprayer 10C has all the elements of the water demineralizing sprayer 10A of Fig. 1 with the exception of the following: the sprayer 10C has a separator element 82 which can be a screen or porous disc filter or a perforated disc which permits water to flow therethrough and yet prevents resins from flowing through. Between the separator disc 82 and the screen 64 located at the nozzle end of the sprayer is a biasing spring 84 which biases disc 82 away from spring 64 towards the spray end of the sprayer to maintain the integrity of the resin bed. When the sprayer is first assembled, and the demineralizing resin is fresh, the spring is fully compressed or blocked and the separator disc 82 is located close to screen 64. As the sprayer is used and the resin is spent, the volume of the resin decreases and the biasing spring forces the separator disc 82 down towards the nozzle end of the sprayer maintaining the integrity of the resin bed 20A. This construction permits the horizontal resin bed to remain compacted. In Fig. 5, the resin is about three-quarters spent. The wall 22A of the hollow body 12 has a transparent strip window 86 (shown in phantom) running down the full length of the body. The strip window has an indicator dot 88. When the height of the resin bed 21 is at the indicator spot 88, the resin is spent and the sprayer is no longer able to function as a water demineralizer spring. If color-changing resin is employed, the color of the resin can be viewed through the strip window.

Referring to Fig. 4, the water demineralizer sprayer 10 identical to the water demineralizer of Fig. 1 with the exception that the resin of resin bed 20A is spent and the resin bed height 21A has been displaced down towards the nozzle end (compare main bed height 21 in Fig. 1). The wall 22 of the sprayer is made of a transparent material and the resin bed height can be easily ascertained visually. When the resin bed height 21A reaches the top edge of the indicator strip 66 (shown in phantom), the user of the sprayer then knows that the resin of the resin bed is exhausted and can no longer provide a demineralized water spray.

After the sprayer is utilized, it is disconnected from the hose with the central cavity of the body remaining filled with water and resin. When the sprayer is being used and a water pressure is exerted against the resin bed, the main bed top remains substantially perpendicular to the inner wall of the body. However, once

th water pressure is reduced over the top portion of the resin bed, and the volume of the main bed has commenced to decrease because of the exhaustion of the resin, the unrestrained top of the resin bed can slurry with the water in the central cavity. Accordingly, when the sprayer is laid down for storage or the like, frequently the top of the resin bed 21B will repose at an angle as shown in phantom in Fig. 4. When the sprayer is to be utilized again, the sprayer can be shaken to slurry the resin at the top of the bed and held vertically to allow the bed to soften and form a top surface 21A which is perpendicular to the inner surface of the wall 22. The pressurized water flow from the hose maintains the top shape of the bed and keeps the bed compact and eliminates short circuiting, or channeling, through the bed during use. (It is generally believed that a "loose" horizontal bed is subject to short circuiting in the bed; however, in the present invention, when the resin has settled, if the resin is re-slurried with the remaining water in the central chamber before use and held in a vertical position to allow the resin bed to form a flat top perpendicular to the inner surface of the wall 22, there appears to be no short circuiting of the water flow through the resin bed.) Short circuiting, or channeling, occurs when water is able to circumvent the resin bed and thus is not demineralized. In sprayers constructed in the configuration shown in Figs. 3 and 5, the risk of channeling is further alleviated since the compressed sponges and bias spring maintain the shape of the bed even as the volume of the bed decreases with the exhaustion of the resin.

Referring to Figure 6, an alternative embodiment of the water demineralizer sprayer 110 is illustrated. The sprayer 110 comprises a longitudinal hollow body 12 similar to the hollow bodies illustrated in Figures 1 - 5, a hollow outlet cone 114 attached to the outlet end of the body 12 and a hollow inlet piece 118 attached to the inlet end of the body. The outlet cone 114 has a cone section 130, a sleeve section 132 adapted to receive the outlet end of the body 12 and a nozzle section 136 adapted to receive spray nozzle tip 116. The end of the body 12 abuts up against the shoulder 160. The body 12 is welded into the sleeve of the cone section 114 or glued into the sleeve section. This forms a strong watertight union. A retainer screen or porous element 120 to support the resin is positioned and fixed within the hollow outlet cone 114 tip to create collection chamber 134. Chamber 134 is in communication through screen 120 with the resin bed 24 and is in communication with the spray nozzle tip 116 through bore 123 of retainer wall 122.

The hollow inlet pi ce 118 has a hose attachment section 140, a sleeve section 142 which receives the inlet end of the hollow body 12 and a view s ction 144. The hollow inlet piece is transparent in order that the resin can b viewed directly either indicating that the color change with color-changing resin or to determine the height of the resin bed. Alternatively, the hollow inlet piece can be translucent to determine the height of the resin bed as a shadow when the sprayer is placed in a strong light source. The inlet end of the body 12 is welded or glued into the sleeve section 142 with the end of the body section 12 abutting the shoulder 162 of the hollow inlet piece. The hose nipple section has a hose nipple 46 with internal hose nipple threads 48. The end of the hose nipple section terminates in a restraining wall 152 which is adapted to receive on the hose nipple side a washer which can be a restraining washer as described above with respect to Figure 1 and a screen 64A. The element 64A can be a filter or other semi-permeable element which permits water flow while retaining the resin. The element 64A is the inlet end of resin chamber 50A which is an extension of the central cavity 24 and which, when the sprayer is freshly charged with resin, is filled with resin 20. The resin in chamber 50A minimizes eddying effects of inlet water through screen 64A. As the resin becomes exhausted from use and its volume is reduced, the height of the resin bed recedes from element 64A towards the outlet or discharge end of the sprayer. In the particular embodiment shown, when the top of the resin bed 21B reaches the indicator line 132 (shown in phantom), the user is warned that the resin bed is exhausted and the sprayer is no longer effective for demineralization. In the embodiment shown, the resin bed will be exhausted when the top of the resin bed 21B resides at the inlet end of the body 12. Alternatively, if the resin bed is a color-changing resin bed, the user can easily see the color of the resin bed by viewing through the transparent walls of the hollow inlet piece 118. If the piece 118 is translucent, the color of the resin bed will not be as visible and the user will have to determine demineralization capacity of the resin by viewing the height of the resin bed through the piece 118 by holding the sprayer up to a strong light source as discussed above.

Referred to Figures 7 and 8, an alternative embodiment of the hollow outlet cone is illustrated in these figures. The hollow outlet cone 114A has a cone section 130A, a sleeve section 132A, a nozzle section 136A and a collection chamber 134. Within the collection chamber, there are a plurality of support flanges 126. The

support flanges 126 in combination with the shoulder 160A support a screen, or a porous filter, or a perforated plate 64B which supports the resin bed in the central chamber 24 and prevents the resin 20 from entering the collection chamber 134. In all other respects, the hollow outlet cone 114 is similar to hollow outlet cone 114 illustrated in Figure 6.

Referring to Figure 9, an alternative embodiment of the hollow outlet cone 114B is illustrated. The hollow outlet cone 114B has a cone section 130B, a nozzle section 136B and a sleeve section 132B to receive the outlet end of the body 12 in the same fashion as the hollow outlet cones 114 and 114A of Figures 6 through 8 above. This cone section has a smaller screen, porous filter or perforated plate 64C than the cones of Figures 6 - 8. This permits the sprayer to be reduced slightly overall in length since a portion of the resin bed is now in the cone, or alternatively to increase the capacity of the sprayer, and it permits the color of color-changing resin to be observed to determine resin exhaustion. Thus, in the hollow outlet cone 114B, the size of the collection chamber 134 has been greatly reduced and the loss of volume of this chamber has been dedicated to receiving resin 20 to help create the resin bed. In a sense, in this embodiment the central cavity 24 extends into the hollow outlet cone 114.

The fifth embodiment of the spray water demineralizer 210, which is illustrated in Figure 10, comprises a spray body 212 and a resin cartridge 214. The spray body 212 comprises a nozzle section 216, a hose nipple section 218 which are adjoined to a manifold section 220. Within the manifold section there is a flow pipe 224 which is connected to the inlet 222 of the hose nipple section which flows to outlet 226 positioned above the receiver 228 for the resin cartridge. The resin cartridge 214 comprises a cup 230 and a resin canister 238. The cup 230 has cylindrical side wall 232 connected to a closed bottom 234. The top of the cup has an open top 236 which is received by the receiver 228, conveniently with a male/female threaded connection. To prevent water leakage, the connection between the cartridge and the body at the receiver will have washers and o-rings to prevent water from leaking out. The resin canister is an off-the-shelf resin canister, such as the resin canister produced by DI TECH. The cup is designed to support the canister off the bottom with support 235 to prevent water flow. Water flows from the flow pipe 224 into the top of the canister that has perforations (not shown). The water flows through the canister where it is demineralized by the resin as

discussed herein. The treated water exits the bottom of the canister through perforations (not shown) and flows up along the side of the canister on the inner walls of walls 232 and flows out the open top of the cup into collection chamber 248. Then the water is sprayed out through the metering spray nozzle tip 116 in the same manner as water is sprayed out of the hand-held sprayer demineralizers of Figures 1-8.

If the sprayer water demineralizer is fed with soft water from a pressure source, such as the classical soft water treatment wherein the water is passed over an ion exchange bed to substitute sodium for the cations and chlorine for the anions, the water demineralizer sprayer need only be charged with an ion-exchange resin to remove the sodium cation. The resulting rinse water will have a low pH. However, superior results are obtained when a mixed anion and cation resin employed since both the sodium cation and the chlorine anion are removed to yield a neutral water which is substantially free of all cations and anions except for hydrogen and hydroxyl ions.

The sprayer can also utilize water from a reverse osmosis unit which can reduce the dissolved solids content of water to about 10 ppm. When water processed by reverse osmosis is used in conjunction with the water demineralizer sprayer, a superior rinse fluid is provided which is substantially free of cations and anions except hydrogen and hydroxyl ions. Further, since most of the anions and cations are removed from the water during the reverse osmosis treatment, the life of the resin in the water demineralizer sprayer will be extended by several orders of magnitude.

For embodiments of the demineralizing sprayer which are operated in a horizontal orientation, i.e., the embodiments of Figures 1-6, a column of resin of 1.5" diameter and 12.5" length having an aspect ratio of a little over 7 (length divided by diameter) containing about 13.5 cubic inches of resin, a flow rate of about 60 fluid ounces of water (TDS 700 ppm) per minute at a water pressure of 60 psi, will provide about 25-30 minutes of continuous flow before exhaustion using the DOWEX resin set forth below. Average tap water throughout the country has a TDS content of about 450 ppm. At the indicated flow rate, the device will reduce the dissolved solids content of 200 ppm water to about 1 ppm, 450 ppm water to about 3 ppm, 700 ppm water to about 4 ppm and 1,000 ppm water to about 5 ppm before exhaustion. Although lower aspect ratios can be used for the column of

resin, such as an aspect ratio of 4:1, columns with higher aspect ratios more efficiently treat the water and permit the efficient use of horizontal columns, which otherwise might present a problem with channeling as the resin demineralizing capacity is consumed. As a general rule of thumb for practice of the present invention, the water flow per cubic foot of resin (semiconductor-grade mixed resin) in a column with a length to width ratio (aspect ratio) of at least 4:1 should be in the range between about 12 to about 14 gallons per minute.

To increase the efficiency of the sprayer, for the convenience of the user and to prevent waste, the sprayer is optionally fitted with a conventional garden hose trigger control valve. The trigger control valve has a female hose nip inlet and a male hose nip outlet which can be screwed into the inlet end of the water demineralizer sprayer. The use of a trigger control valve permits the flow of water to be stopped at any time so that resin capacity is not wasted.

Illustrated in Figs. 12 and 13 are further embodiments of the hand-held demineralizing sprayer. In these embodiments, a bottle 400, which is of a size that can be easily carried in the hand, is filled with tap water. The bottle 400 is preferably a clear or translucent plastic material, or will have a clear indicator window, which will allow the user to readily determine the amount of water remaining in the bottle. Uptake tubing 402 that draws the water up for discharge has a resin chamber 404 in-line with the tubing which is constructed in accordance with the previous des§criptions of the resin chamber and is filled with ion exchange resin (not shown). The spray nozzle 410 at the discharge end 408 of the tubing of the sprayer of Fig. 13 creates a pressure in the resin chamber 404 and forces water to and through its outlet 412 to form a fine spray 414 through the nozzle 410. As in the previous embodiments, the metered flow of water through the resin chamber 404 allows effective and efficient use of a small volume of resin to demineralize the water. The uptake of the water is effected either by using a conventional trigger spray pump device (as shown in Fig. 12), which creates a vacuum upstream from the resin chamber 404 to pull the water upward into a small pump chamber 416, then applies pressure to water in the pump chamber 416 to force it out of the outlet, or, as shown in Fig. 13, by providing an air pump 418 to inject air pressure into the bottle which, when an on-off valve 420 upstream from the resin chamber 404 is opened, forces the water through the resin chamber 404 and out of the spray nozzle 410.

The embodiments of Figs. 12 and 13 provide a simple and inexpensive means for real time conversion of tap water to demineralized water that can be conveniently used for interior applications, such as cleaning mirrors or rinsing delicate surfaces that are susceptible to water spots, e.g., highly polished furniture, or for misting plants, such as orchids, that are subject to burning or other damage or which end up with water spots on their leaves and flowers if ordinary tap water is used and not wiped off. While it may be easy to fill a common spray bottle with deionized water, typically, this water must be purchased at a store and may run out at an inappropriate time. The present invention assures that a much more long-lasting supply of demineralized water is available, since the supply will last as long as the resin is active. Then, depending upon the resin used, it may be possible to regenerate the resin using ordinary household chemicals, or a replacement filter can be purchased at relatively little cost.

While the above figures are provided for semiconductor-grade demineralizing resin, a variety of ion exchange resins may be employed in the present invention. DOWEX MONOSPHERE MR-3 mixed ion exchange resin, available from Dow Chemical Company, is a hydrogen/hydroxy (H^+/OH^-) ion mixed bed resin, semiconductor-grade, having a particle size distribution (microns) of between 550 and 590 ± 50, which is suitable for the present invention. Preferably the mixed resin is a 10% dvb cross-linked 98% regenerated cation resin (about 38% by volume) mixed with a highly regenerated hydroxy regenerated anion resin (about 62% by volume). However, other mixed resins may be used. This resin is a mix of DOWEX MARATHON C hydrogen cation (H^+) and DOWEX MONOSPHERE 550A hydroxy anion (OH^-) resins. Other hydrogen/hydroxy ion resins, such as Puro-Lite NRW-37 mixed bed resin, may also be employed in the present invention. Other grades of demineralizing resins may be used; however, they may have different ion-exchange rates. The necessary information to calculate the bed size to obtain the desired spray volume and demineralization is available from the manufacturer, and the outlet aperture dimensions and resin bed size may be adapted as needed to provide the appropriate flow and residence time within the resin to produce the preferred 50 ppm TDS or less of deionized water output (no more than 100 PPM TDS). As stated above, the resin may possess a color-changing property such that the resin changes color when the ion exchange capacity of the resin has been exhausted,

The present invention possesses significant advantages over the prior art and provides economical and effective means to obtain the wat r quality once reserved for commercial establishments for rinsing of many different surfaces. The outlet spray aperture in direct combination with the deionizing resin bed permits metering capability of the rate of water flow through the devices which controls the rate of use of the resin as well as the efficiency of the deionization process, so that large amounts of resin need not be employed to provide an effective rinse. Because the water flow is so controlled, only a small volume of resin is needed, making a lightweight, portable, and in most cases, completely hand-held, device possible. The portable sprayer can be configured to connect directly to a water source, such as a garden hose, or can be a container which can be filled with tap water that can be readily carried around by the user and refilled at any available tap. The key to the invention is the incorporation of the deionizing capability within the sprayer itself to provide real time conversion of ordinary tap water into demineralized water to provide a superior rinse. Another significant advantage of the invention is that it allows a significantly smaller volume of water to be used than would otherwise be used without the metering function provided by the outlet aperture.

Another advantage of the present invention is the fact that the device is environmentally friendly. The device removes toxic heavy metals from the treated water. The device minimizes the amount of water needed to rinse a surface. For a surface that is lightly dusty or lightly soiled, the simple rinsing of the surface with the present invention will normally clean the surface and leave it spot-free without the use of soap, detergents or other cleaning solutions. Lightly dusty autos can be washed, i.e., rinse washed, with the present device using about one gallon of water total. This represents a tremendous water savings. Most conventional auto wash operations require significantly more water. The resin is rechargeable by known methods. The body of the device, made from plastic, can be recycled.

It will be evident that there are additional embodiments which are not illustrated above but which are clearly within the scope and spirit of the present invention. The above description and drawings are therefore intended to be exemplary only and the scope of the invention is to be limited solely by the appended claims.

CLAIMS

I CLAIM:

1. A lightweight, portable device for dispensing a spray of substantially demineralized water, the device comprising:

a sealed hollow body having a cavity bounded by a wall, a single inlet at its inlet end for introducing tap water under pressure into the cavity, and a single outlet at its outlet end for discharging a spray of demineralized water;

a chamber located in the cavity within said hollow body, said chamber having end in fluid communication with said inlet for receiving tap water, said chamber having a discharge end in fluid communication with said single outlet for discharging demineralized water;

a first porous separator disposed in the receiving end of said chamber;

a second porous separator disposed at the discharge end of said chamber;

a resin bed confined within said chamber between said wall and said first and second porous separators, said resin bed for effecting an ion exchange of said tap water under pressure to produce demineralized water; and

an outlet spray nozzle connected to said hollow body in fluid communication with said single outlet for limiting the discharge flow rate of demineralized water from the hollow body and consequently limiting the flow rate of tap water under pressure through said resin bed so that the tap water has a sufficient residence time in said resin bed to produce a substantially demineralized water by ion exchange in the resin bed, and for discharging a spray of said substantially demineralized water.

2. A device as in Claim 1 wherein said hollow body comprises a generally cylindrical tube and said inlet comprises a threaded hose nip for attachment to a standard hose fitting.

3. The device according to Claim 2 wherein the outlet end and the inlet end are disposed at opposite ends of said hollow body.

4. A device as in Claim 3 further comprising a hollow cone at said outlet end of said hollow body, said hollow cone having an apex and said outlet spray nozzle is disposed at said apex.

5. The device as in Claim 4 wherein said hollow cone is transparent and the color of a portion of said resin bed can be viewed through said hollow cone, and said portion of said resin bed changes color when its water demineralization capacity is spent.

6. A device as in Claim 1 wherein said outlet aperture is generally oval in shape.

7. A device as in Claim 1 wherein said outlet spray nozzle limits the flow rate of demineralized water through the outlet to permit sufficient ion exchange of tap water within said resin bed so that the substantially demineralized water produced has a total dissolved solids content of less than 100 ppm.

8. The device as in Claim 1 wherein said outlet spray nozzle limits the flow rate of demineralized water through the outlet to permit sufficient ion exchange of tap water within said resin bed so that the substantially demineralized water produced has a total dissolved solids content of less than 50 ppm.

9. A device as in Claim 1 wherein said resin bed is semiconductor-grade mixed resin and said outlet spray nozzle limits the flow rate of demineralized water through the outlet to less than 14 gallons per minute per cubic foot of said resin bed.

10. A device as in Claim 1 wherein said water source is a hose connected to a tap.

11. A lightweight, portable device for dispensing a spray of substantially demineralized water, the device comprising a sealed hollow body having a first chamber, a second chamber, a fluid conduit, a single inlet for introducing tap water under pressure, and a single outlet for discharging demineralized water as a spray;

the first chamber having an inlet for receiving demineralized water, the outlet of the first chamber being the outlet for the hollow body;

the second chamber having an inlet for receiving tap water under pressure and an outlet in fluid communication with the inlet of the first chamber for introducing demineralized water under pressure into the first chamber,

the fluid conduit in fluid communication with the inlet of the hollow body for receiving tap water under pressure and in fluid communication with the inlet of the second chamber for introducing tap water under pressure into the second chamber;

a first porous separator disposed in the second chamber and in fluid communication with the inlet of the second chamber;

a second porous separator disposed in the second chamber and in fluid communication with the outlet of the second chamber;

an ion exchange resin bed confined within said second chamber between said first and second porous separators, said resin bed for effecting an ion exchange of tap water; and

an outlet spray nozzle connected to said hollow body in fluid communication with said single outlet for limiting the discharge flow rate of demineralized from the hollow body and consequently limiting the flow rate of tap water under pressure through said resin bed so that the tap water has a sufficient residence time in said resin bed to produce a substantially demineralized water by ion exchange in the resin bed, and for discharging a spray of said substantially demineralized water.

12. A lightweight, portable device for dispensing a spray of substantially demineralized water, the device comprising a sealed hollow body having a first chamber, a fluid conduit, a single inlet for introducing air into the first chamber, and a single outlet for discharging demineralized water as a spray;

the first chamber adapted to hold tap water; and

the fluid conduit having an inlet end and an outlet end, and in fluid communication with the first chamber and the outlet of the sealed hollow body, the fluid conduit having a first porous separator disposed at its inlet end, a second porous separator disposed at its outlet end, and ion exchange resin beds disposed

in the fluid conduit between the first porous separator and the second porous separator, the outlet end of the fluid conduit in fluid communication with the outlet of the sealed hollow body, the inlet end of the fluid conduit positioned in the first chamber to receive tap water;

means for introducing air under pressure into the first chamber to force tap water from the first chamber into the inlet end of the fluid conduit through the ion exchange resin bed to substantially demineralize the tap water, into the outlet of the hollow body; and

an outlet spray nozzle connected to said hollow body in fluid communication with said outlet of the hollow body for limiting the discharge flow rate of demineralized water from the hollow body and consequently limiting the flow rate of tap water through said resin bed so that the tap water has sufficient residence time in the said resin bed to produce the substantially demineralized water and ion exchange in the resin bed and for discharging a spray of substantially demineralized water.

13. A lightweight portable device for dispensing a spray of substantially demineralized water, the device comprising a sealed hollow body having a first chamber, a fluid conduit, a single inlet for introducing air into the first chamber, a single outlet for discharging demineralized water as a spray, and a vacuum pump;

the first chamber adapted to hold water;

the fluid conduit having an inlet and outlet end in fluid communication with the first chamber and the outlet of the sealed hollow body, the fluid conduit having a first porous separator disposed at its inlet end, a second porous separator disposed at its outlet end, and an ion exchange resin bed disposed in the fluid conduit between the first porous separator and the second porous separator, the outlet end of the fluid conduit in fluid communication with the outlet of the sealed hollow body, the inlet end of the fluid conduit positioned in the first chamber to receive tap water;

the vacuum pump drawing water from the first chamber through the fluid conduit into the vacuum pump and forcing the demineralized water through the outlet of said sealed hollow body; and

an outlet spray nozzle connected to said hollow body in fluid

communication with said vacuum pump, the outlet spray nozzle limiting the flow rate of demineralized water through the resin bed so that the tap water has sufficient residence time in the resin bed to produce a substantially demineralized water ion exchange in the resin bed, and for discharging a spray of substantially demineralized water..

14. The lightweight portable device according to Claim 12 including a valve means disposed between the outlet end of the fluid conduit and the outlet spray nozzle for controlling the release of substantially demineralized water through said outlet spray nozzle.

15. A device as in Claim 1 wherein said resin bed comprises a mixed resin of H^+ and OH^- demineralizing resins.

16. A device as in Claim 1 further comprising means for determining when the water demineralizing capacity of said resin bed is spent.

17. The device according to Claim 16 wherein the means for determining when the water demineralizing capacity in said resin bed is spent comprises the wall of said hollow body adjacent said chamber being at least partially transparent or translucent so that the height of the resin bed therein can be visually observed, the demineralization capacity of said resin bed being spent when the height of said resin bed contracts to a predetermined level.

18. The device according to Claim 17 wherein a marker is located on the wall of the hollow body to indicate the predetermined level of the height of the resin ed which indicates when the water demineralizing capacity of said resin bed is spent.

19. The device according to Claim 17 wherein the wall of said hollow body has a translucent or transparent portion extending the full length of said hollow body.

20. The device according to Claim 17 wh r in the wall of said hollow body has a translucent or transparent window.

21. The device as in Claim 1 wherein the device includes a porous separator disk adapted to move in the chamber, the porous separator disk positioned at one end of the resin bed near one of said first and second porous separators, and a compressed sponge disposed between said third porous separator disk and said one of said first and second porous separators and biased to separate the porous separator disk from one of the porous separators to compact the resin bed.

22. The device as in Claim 1 wherein the device includes a third porous separator disk adapted to move in the second chamber, the porous separator disk positioned at one end of the resin bed near one of said first and second porous separators, and a spring means disposed between said porous separator disk and said one of said first and second porous separators and biased to separate the porous separator disk and said one of said porous separators to compact the resin bed.

23. The device as in Claim 1 wherein a ratio of a height of said resin bed to a width of said resin bed in said second chamber is at least about 4.

24. In a lightweight, portable device for demineralizing tap water and dispensing a spray of substantially demineralized water, the device comprising a hollow body having a single inlet, a single outlet and dimensions whereby said hollow body can be fully supported in a user's hands; a first chamber within said hollow body having a first inlet end in fluid communication with said inlet, and a first outlet end, said first inlet end for receiving tap water under pressure from a water source; a second chamber within said hollow body in fluid communication with said first chamber, said second chamber having a cylindrical shape, a second inlet end and a second outlet end, said first outlet end in fluid communication with said second outlet end; a resin bed retained within said second chamber by first and second porous separators, said resin bed for effecting an ion exchange of tap water; and an outlet sprayer nozzle connected to said hollow body in fluid

communication with said second outlet, and said outlet in fluid communication with said outlet end for discharging substantially demineralized wat r outside of said hollow body, the improvement comprising:

said outlet spray nozzle limiting water flow through said outlet spray nozzle and said resin bed to ensure a sufficient tap water residence time within said resin bed to produce substantially demineralized water having less than 100 ppm total dissolved solids.

25. The device of Claim 24 wherein said hollow body is a generally cylindrical tube and said first inlet end is attached to a hose which is attached to the water source.

26. The device of Claim 24 wherein said hollow body is a bottle and further comprising a pumping means, wherein said bottle is filled with tap water from the water source.

27. The device of Claim 24 wherein the resin bed is semiconductor-grade mixed resin and said water flow through said resin bed is less than 14 gallons per minute per cubic foot of said resin bed.

28. The device of Claim 24 wherein said substantially demineralized water has less than 50 ppm total dissolved solids.

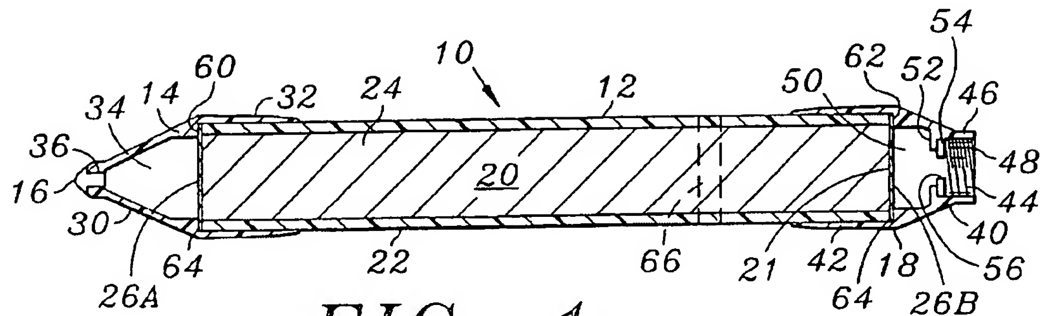

FIG. 1

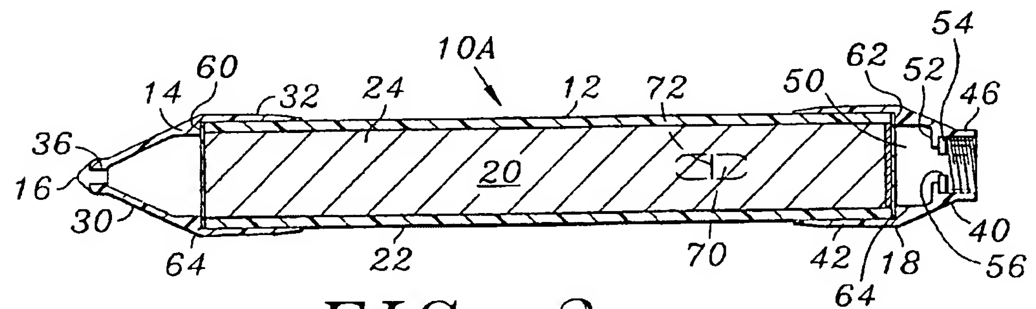

FIG. 2

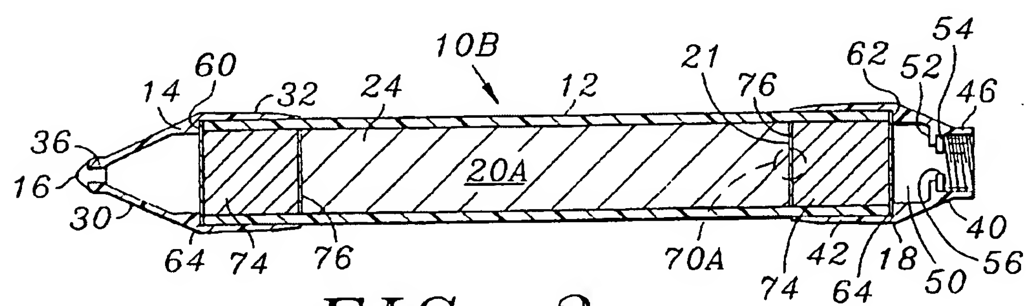

FIG. 3

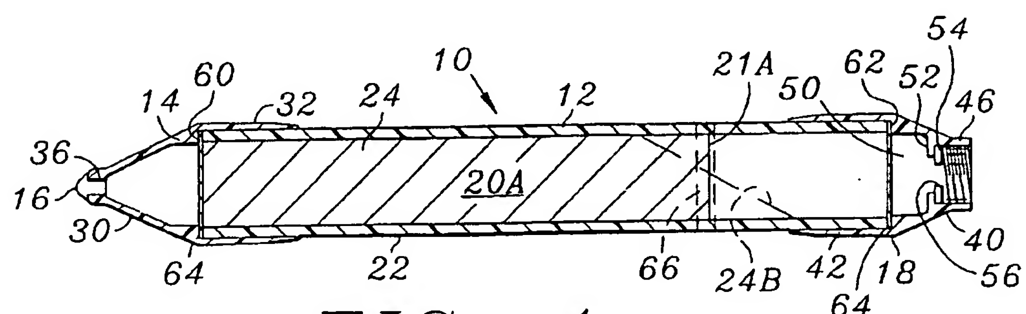

FIG. 4

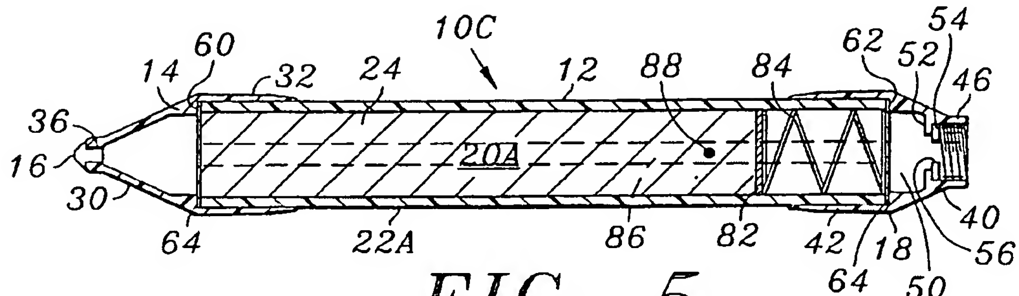

FIG. 5

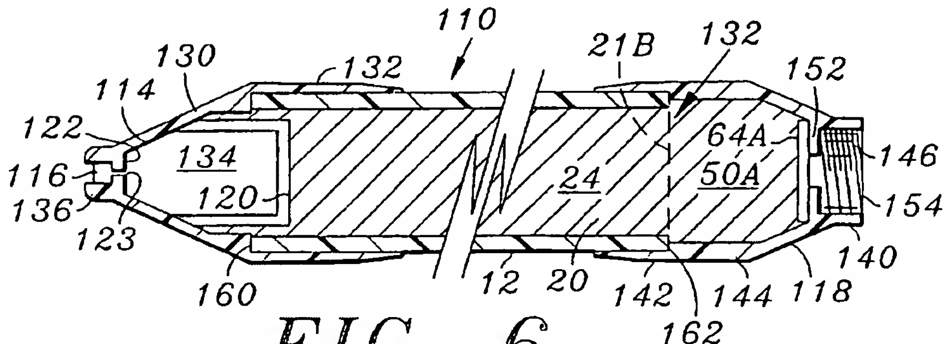

FIG. 6

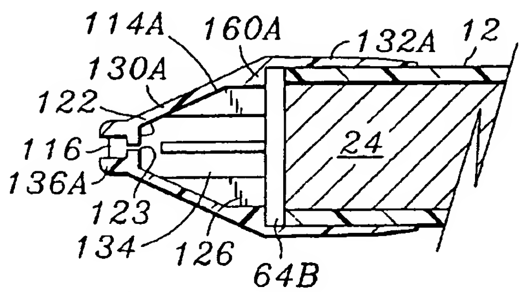

FIG. 7

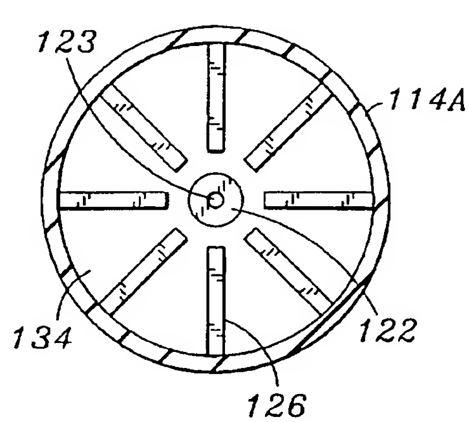

FIG. 8

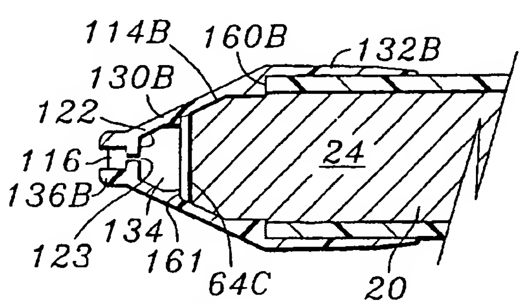

FIG. 9

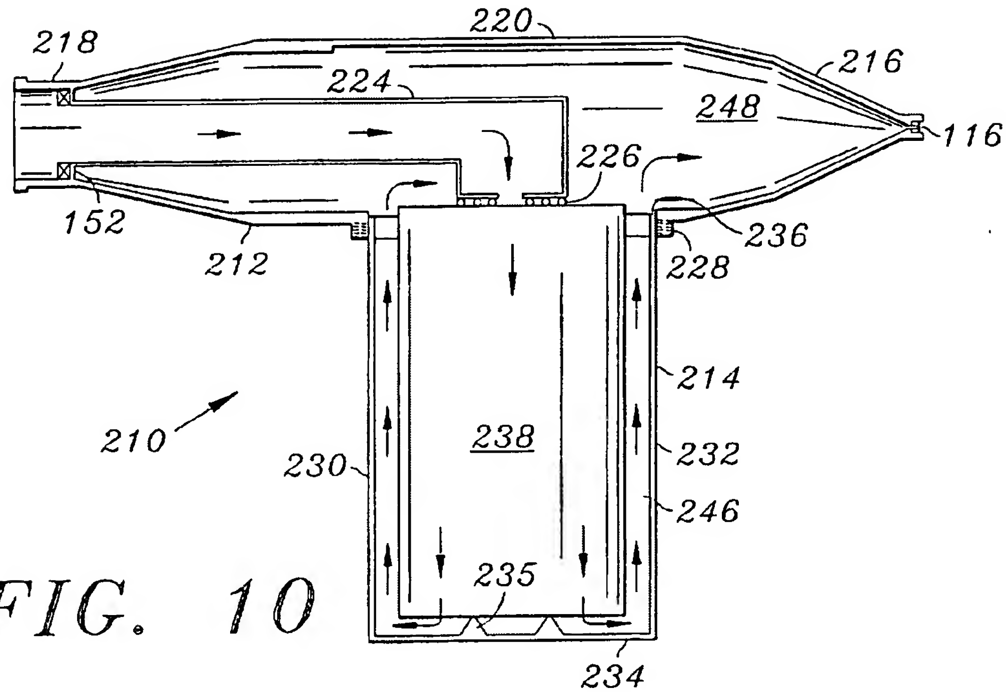

FIG. 10

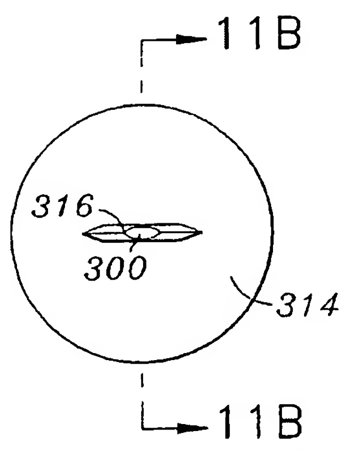

FIG. 11A

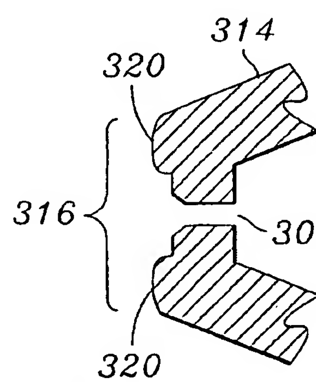

FIG. 11B

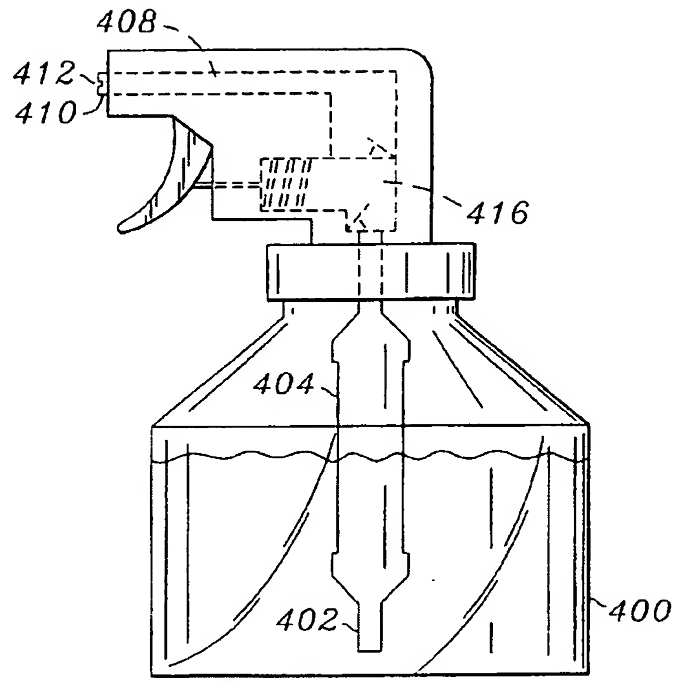

FIG. 12

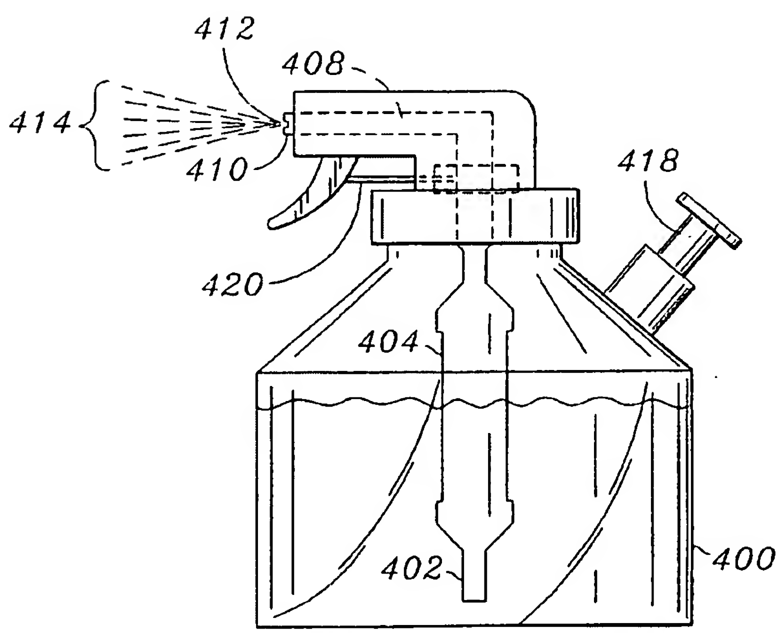

FIG. 13

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/12250

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B01J47/00 B05B11/00 B05B9/08 B05B1/00 C02F9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B01J C02F B08B B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 412 630 A (PLAFOUDZIS GEORGES) 31 December 1965 see the whole document ---	1,3-5,7, 8,10,11, 15,16, 24,28
A	AU 54933 80 A (AUSTRALIAN WATER PURIFICATION PTY. LTD.) 30 July 1981 ---	1-3,11
A	EP 0 709 341 A (MARINE BIO CO LTD) 1 May 1996 see the whole document ---	1-3,10
A	BE 699 122 A (AUXIMAZ) 3 November 1967 see the whole document --- -/--	1-3

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 November 1997	11. 12. 97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lapeyrere, J

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/12250

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 3 814 292 A (DARGOLS B) 4 June 1974 see the whole document -----	13

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INTERNATIONAL SEARCH REPORT

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